

Effect of Supplementary Feeding Strategies on the Performance of Stall Fed Dual-purpose Dairy Cows Fed Grass Hay-based Diets**

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ABSTRACT : Supplementary feeding strategies were evaluated from pre-calving throughout lactation on 24 dual-purpose Mpwapwa breed cows in their second or greater lactation, weighing 246-455 kg. The Mpwapwa breed is an established breed of 4 *Bos indicus* breeds and 8% of *Bos taurus*. The cows were penned and stall-fed individually. Eight weeks before calving to eight weeks after calving, the cows were divided into two groups and offered hay *ad libitum* with either 2 kg DM (L) or 4 kg DM/day (H) concentrates. Nine weeks after calving half of the cows on L-level continued with 2 kg DM/day (L-L) while the remainder received 4 kg DM concentrate daily (L-H). Half of the cows on H-group continued with 4 kg DM/day (H-H) while the remainder received 2 kg DM/day (H-L). The concentrate mixture comprised of sunflower seed cake (33%) and maize bran (67%). The cows consumed all the concentrate offered. Hay DM intake was similar (6.8 kg/day) and tended to decrease the last two weeks before calving increased again after calving. Live weight change and body condition score were similar across treatments before calving but differed after calving ($p < 0.05$). Heavier cows with higher condition score pre-calving had a higher body weight loss and regained weight later. After treatment reallocation, live weight change and condition differed between treatments ($p < 0.05$). Calves were allowed to suckle milk from one quarter. The amount of milk suckled and calf weight gains were not significantly different between treatments. The cows were removed from the experiment when the milk yield was below 4 kg per day. Cows on treatment H produced 6.2 kg and on treatment L 5.0 kg saleable milk/day ($p < 0.05$) during the first 8 weeks *post partum*. During the period 9-18 weeks *post partum* the saleable daily milk on H-H, L-H, H-L and L-L were 5.2, 4.8, 4.7 and 4.3 kg, respectively ($p > 0.05$). (*Asian-Aust. J. Anim. Sci.* 2003, Vol 16, No. 3 : 359-367)

Key Words : Dual-purpose Cows, Plane of Nutrition, Feeding Strategy, Milk Yield, Live Weight, Body Condition.

INTRODUCTION

Low productivity of dairy cows in Tanzania and many other countries in the tropics and sub-tropics is generally accepted as being the result of the low genetic potential of the available breeds and poor quality of feed resources, coupled with substantial fluctuations in food availability. Zebu cattle (*Bos indicus*) are found in several tropical countries and are well suited to low quality feed resources but their dairy potential is poor and they have low growth rates (Syrstad 1991; Ugarte 1991).

In such situations emphasis was directed towards strategies to improve the genetic potential of the indigenous breeds through incorporation of genes from temperate breeds (Syrstad, 1991). This strategy led to development of dual-purpose breeds such as the Mpwapwa breed found in Tanzania (Macha, 1986).

Dual-purpose cows perform better than the traditional

Zebu breed (Kasonta and Mkonyi, 1991) but their current performance is lower than the expected breeding goal. The average age at first mating has been reported to be 30 months (Macha, 1986). This could be due to nutritional management being sub-optimal, leading to lower than expected growth rates. Bwire and Wiktorsson (1996) found that the average age and liveweight at puberty of dual-purpose Mpwapwa heifers was reduced to 19 months and 203 kg respectively by the use of concentrate supplementation of 1 kg DM/day (13 MJ/kg DM, 160-200 g CP/kg DM) during the dry season. This gives an indication that provision of optimum levels of nutrition to mature dual-purpose dairy cows might result in a significant improvement in lactation performance.

The response to different levels of nutrient supply in dairy cows with high genetic potential for milk yield depends among other factors on stage of lactation, the critical period being from calving until peak milk production. Immediately after calving the cow's appetite is such that the intake of energy can rarely match the cow's requirement at higher yields, and consequently live weight falls as body tissue is mobilised as a source of energy (Bines, 1979). Therefore feeding dairy cows in early lactation presents a special problem because often the cow is either not offered adequate amounts of feed or cannot consume enough to supply the energy needed for maximum milk production, and therefore is prone to negative energy

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balance (Allen, 1996). A feeding pattern that leads to cows with sufficient mobilisable body fat at calving seems logical, but excess fat on the cow can reduce feed intake after calving by restricting gut capacity and by releasing larger than normal amounts of free fatty acids into the blood that depresses appetite (Bines, 1979).

Understanding the relationship between body condition pre-calving, dry matter intake and milk yield for dual-purpose dairy cows could lead to a more effective management strategy and milk production system. Although there is information on the effect of pre-calving nutritional status on subsequent milk production in high yielding dairy cows (Land and Leaver, 1980; Garnsworthy and Topps, 1982; Garnsworthy and Jones, 1987), data are scarce for dual-purpose dairy cows with high levels of *Bos indicus* breeds and low level of *Bos taurus* dairy breeds. Therefore the broad objective of this study was to evaluate supplementary feeding strategies that could lead to appropriate feeding and management systems around calving for successful lactation performance of dual-purpose Mpwapwa dairy cows.

MATERIALS AND METHODS

Animals and management

The experiment was conducted at the Livestock Production Research Institute (LPRI), Mpwapwa, Tanzania, approximately 36° 21' E longitude and 6° 21' S latitude. The Research Institute lies in the semi-arid zone of central Tanzania which is characterised by low and erratic rainfall averaging 660 mm per annum, with mean daily temperature ranging from 24 to 29°C. The elevation is 1,100 m above sea level. The experiment started during the dry season, at the beginning of July 1999 and continued throughout lactation until a minimum of 4 kg milk per day was registered. Twenty four Mpwapwa breed cows in their second, third and fourth lactation were obtained from LPRI, Mpwapwa. The breed composition is: Red Sindhi 32%, Sahiwal 30%, Tanzania Short Horn Zebu (TSZ) 19%, Boran 11% and *Bos taurus* 8% (mostly Ayrshire) (Kiwuwa and Kyomo, 1971). The experiment commenced eight weeks before calving when the cows weighed 246-455 kg. The body condition of cows on H and L plane of nutrition at the onset of the study was 6.7 and 6.8, respectively, on a scale 1-9 (Nutbal user's guide, 1993). The cows were treated for worm infestation before commencement of the experiment and every after three months thereafter using Valbezene (Albendazole 10% w/v), a total spectrum anthelmintic for cattle. The animals were dipped once a week using SUPADIP (DFP 110 w/v) to control tick borne diseases. Also they were vaccinated against Black Quarter and Anthrax diseases using Blanthrax vaccine according to the Institute's disease control schedule.

Feeds and feeding of experimental animals

The cows were penned and stall-fed individually. For feed allocation, it was assumed that total dry matter intake (kg DM/day) of a mature cow is equivalent to 3% of its liveweight. Amount of grass hay consumed was assumed to be equal to around 60-70% of the total dry matter intake and the amount of hay offered should exceed the amount to be consumed by 40%. Grass hay therefore was fed *ad libitum*, while the amount of concentrate mixture was kept constant at 2 or 4 kg DM/day. The grass hay consisted of *Cenchrus ciliaris*, *Panicum maximum*, *Cynodon plectosytachyus*, *Chloris gayana*, *Heteropogon contortus*, and *Rottiboelia exaltata*. These are natural tropical grass species, which are not established as pure stands. Improved pasture management practices, such as fertiliser application has never been undertaken with these grasslands. The grasses were cut by a tractor mower at flowering stage, allowed to dry in the field for 3 to 4 days and later made into hay bales. The concentrate mixture comprised sunflower seed cake (33%) and maize bran (67%) and was fed in a loose mixed form. The cows were fed half of the concentrates in the morning at 8:00 h followed by half of the grass hay. The remaining half of the concentrates were fed at 15:00 h followed by the remaining half of the basal diet (hay) after the evening milking at 16:00 h. The cows on the higher plane of nutrition were offered 4 kg DM of concentrate mixture per day and those on the lower plane of nutrition 2 kg DM per day. All cows had free access to mineral blocks (Maclick Super, manufactured by Welcome Tanzania Ltd) containing Ca (19.95%), P (11.76%), Na (10.26%), Mg (1.10%), Cu (0.16%), Co (0.02%), Fe (0.50%), K (0.006%), I (0.02%), Zn (0.50%), Mn (0.40%), S (0.33%) and Se (0.001%), and placed in the individual feeding stall. Water was available in the water troughs throughout the day. The animals were exercised on their way to the milking parlour twice daily and they were then taken to the dipping site once a week.

Restricted suckling was practised as the calf management system whereby the calves were allowed to suckle their dams before milking for about 30 seconds to stimulate milk letdown. After hand milking of three teats the calves were allowed to socialise with their dams and suckle milk retained in the rear hindquarter which was left un milked in each cow for her calf and the residual milk in the other three teats. Calves were weaned at 45 days post partum. The cows were removed from the experiment and returned to the main herd when their daily milk yield declined below 4 kg.

Experimental design and data collection

Assignment of experimental cows to treatment and placing of animals in individual feeding stalls was undertaken using random numbers (Snedecor and Cochran,

1980). A cross over design was employed, with the following treatment reallocation sequences. Eight weeks before calving the cows were divided into two treatment groups, each including 12 cows: group one received the lower level of concentrate supplementation (2 kg DM per day (L)) while group two received the higher level of concentrate supplementation (4 kg DM per day (H)). Nine weeks after calving, half of the cows on group L were moved to group three and received 4 kg DM of concentrate per day throughout the remaining part of lactation (L-H). Half of the animals on group H were transferred to group four and received 2 kg DM of concentrates per day for the rest of lactation (H-L). The cows remaining in group L and H continued on low (L-L) and high (H-H) planes of nutrition, respectively. The feeds were weighed every day before feeding and the refusals of grass hay were collected and weighed early the next day in order to determine the voluntary feed intake. After the grass hay refusals were weighed, 10% of each collection was bulked for four weeks for proximate chemical analysis. Maize bran and sunflower seed cakes were sampled for proximate chemical analysis before being mixed to form the concentrate mixture. The concentrate mixture, maize bran, sunflower seed cakes and grass hay offered was sampled once before onset of the experiment for proximate chemical analysis and energy estimation. Total dry matter intake was determined by addition of grass hay and concentrates offered.

Body weight measurements and body condition scoring was undertaken once in every fortnight in order to determine body weight change and also change in body condition. Body condition scoring was undertaken by visual observation of the rear and side parts using scale 1-9, (Nutbal user's guide, 1993), where 1, 2 and 3 denotes thin condition, 4 border line, 5, 6, and 7 are optimum condition, while 8 and 9 denote fat condition. The measurements were taken early in the morning before the animals were given fresh food or water, with body condition scoring preceding body weight measurements. Four people were used in body scoring and efforts were made to have a consistent scoring system throughout the experimental period by having the same people in all the scoring occasions.

Milk suckled by the calves was estimated by weigh-suckle-weigh method whereby the calves were weighed once fortnightly starting week 2 post partum until weaning at 45 days post partum. In this method the calves were weighed before suckling and after suckling. The difference in weight was considered to be amount of milk suckled by the calves. The same weight measurements were used to estimate the growth rate of the calves before weaning. Milk yield was recorded every day in the morning and evening milking sessions. The recordings were undertaken throughout lactation starting week 2 after calving. Milk for week 1 was considered to be colostrum and therefore was

not recorded. Average milk yield, and daily milk yield excluded milk suckled by the calf, in this case referred to as saleable milk. Milk samples for determination of milk composition were taken after two weeks, starting week 2 after calving, morning and evening milk samples per cow were handled separately, the values were then combined to provide a mean value for each component. In addition five milk samples were taken per cow after two weeks in order to assess the efficiency of hand milking and calf suckling in emptying the udder starting week 2 post partum until weaning when they were 45 days old. The samples were taken immediately after hand milking, morning and evening samples were handled separately, the respective values were combined to obtain the mean per sample for each cow. The procedure was as follows:

- Sample 1: After cleaning the teats and checking for mastitis, the calf was allowed to stimulate milk let down, then three teats were hand milked, the milk weighed and sample taken.
- Sample 2: After hand milking and milk weighing equal amounts of milk, about (100 mls), were taken from each of the three teats and mixed thoroughly before the calf was allowed to re-suckle.
- Sample 3: The calf was allowed to re-suckle to stimulate milk letdown and then milk from the three teats was taken, mixed thoroughly.
- Sample 4: The calf was allowed to suckle the fourth teat of the rear quarter and then milk was taken from the three teats and mixed thoroughly.
- Sample 5: Milk was taken from the three teats and the fourth teat of the rear quarter and then mixed thoroughly before allowing the calf to go and socialise with her dam.

Laboratory chemical analysis of the feeds, milk samples and energy estimation

DM (dry matter), ash, EE (ether extract), CF (crude fibre), CP (crude protein) and NFE (nitrogen free extract) were determined according to the procedures of AOAC (1985). DM of feeds was determined by oven drying at 105°C for a period of 12 h and ash at 550°C for a period of 3 h. Total nitrogen was determined by Kjeldahl method and CP was obtained from N where, $CP = N \times 6.25$. NDF (neutral detergent fibres) and ADF (acid detergent fibres) were determined according to the procedures of Goering and Van Soest (1970), while *in vitro* digestibility was determined by the procedures of Goering and Van Soest (1970) modified by Mbwire and Udén (1991). The energy concentration of each feed ingredient and the concentrate mixture was estimated by the following formula (MAFF, 1975):

ME (MJ/kgDM)=0.012CP+0.031EE+0.005CF+0.014NFE
where CP, EE, CF and NFE are in g/kg DM.

To determine ME for the basal diet, the grass hay was subjected to an *in vitro* technique to determine dry matter digestibility (DMD %) which was then converted to digestible organic matter in the dry matter (DOMD %) by the following formula (MAFF, 1975):

DOMD %=0.98DMD % - 4.8. DOMD % was converted to metabolisable energy (MJ/kg DM) by the following formula:

$$\text{ME (MJ/kg DM)} = 0.15\text{DOMD \%}$$

Crude protein, ash, butterfat, and total solids of milk samples were determined according to the procedures of AOAC (1985).

Statistical analysis

The statistical analysis was undertaken using the General Linear Model (GLM) procedures in the Minitab statistical software release 12.0 (1998). Voluntary dry matter intake of grass hay, body weight and body weight change, body condition score, milk yield and milk composition were considered as response variables. For hay intake, body weight and body weight change, initial liveweight was considered as a covariate during the analysis. For milk yield and milk composition, stage of lactation and treatments were considered sources of variation. Condition score data were assumed to approximate continuous data in analysis of variance (Nicholson and Butterworth, 1985). When treatment effects were found to be significant, comparison between treatment means was undertaken by Tukey's pairwise procedure in the Minitab statistical software, version 12.0 (1998).

RESULTS

Chemical composition of the feed stuffs, voluntary feed intake and hay selectivity

Chemical composition of the feeds is shown in Table 1. The grass hay had low CP content, below 50 g CP/kg DM. The refusals had lower CP contents compared to that on offer. The fibre contents (ADF and NDF) of the grass hay refusals were higher than that of grass hay offered. Low values of crude protein and high fibre contents in refusals compared to grass hay offered indicates hay selectivity. During the period 14 days before and after calving there was no significant difference in voluntary dry matter intake of grass hay and on average the cows consumed 5.3 and 5.5 kg DM/day on L and H, respectively. There was also a tendency for the general reduction in dry matter intake of hay towards calving and began to increase again on day 2

Table 1. Chemical composition (g/kg DM), and energy (ME MJ/kg DM) content of grass hay, concentrate ingredients, concentrate mixture and grass hay refusals for cows on L-L, H-H, L-H, H-L treatment groups

Feedstuff	Composition ¹							ME	
	DM	CP	ASH	NDF	ADF	CF	EE		NFE
Sunflower cake	932	219	51			345	170	214	12.6
Maize bran	904	116	46			88	85	664	13.8
Concentrate mixture	918	132	65			160	160	445	13.5
Grass hay	940	48	82	761	483				7.7
Grass hay refusals									
L-L	916	29	60	818	538				4.9
H-H	914	28	59	809	545				4.7
L-H	914	26	80	764	485				4.8
H-L	918	29	72	781	515				4.7

¹CP-crude protein; ash: NDF-neutral detergent fibres; ADF-acid detergent fibres; CF-crude fibre; EE-ether extract; NFE-nitrogen free extract; ME-metabolisable energy.

L-L: Cows on low level of concentrate supplementation (2 kgDM/day) throughout the study

H-H: Cows on high level of concentrate supplementation (4 kgDM/day) throughout the study

L-H: Cows shifted from low to high level of concentrate supplementation after 8 w of study

H-L: Cows shifted from high to low level of concentrate supplementation after 8 w of study

after calving (Figure 1, Table 2). All of the concentrate supplements were consumed. After treatment reallocation hay intake was similar among the treatments and on average cows consumed 6.8 kg DM of hay per day.

Body weight, body weight change and body condition

Data for body weight, body weight change and body condition of the cows on L and H before and after calving are shown in Table 3. Body weight did not differ between treatments in the period before calving although cows on L treatment were slightly heavier than those on H from the beginning of the study. The general trend was a decrease in body weight from week 4 towards calving and after calving. Body weight change did not differ between treatments before calving, but cows on L tended to have a greater decrease in body weight than those on H.

After calving body weight differed between treatments ($p < 0.05$) at week 4, 6 and 8 but there was no significant difference between treatments at week 2. The body weight change also differed between treatments ($p < 0.05$) with cows on L having a greater body weight loss than those on H. The cows on H gained weight earlier than those on L. Body condition followed a similar trend, in that before calving no significant difference was found between treatments. After calving, body condition score between treatments differed ($p < 0.05$), with cows on H having a higher score compared to those on L.

Data for body weight, body weight changes and body condition of cows after treatment reallocation 9 weeks *post*

Table 2. Daily hay intake (BDMI, kg DM/day) and total dry matter intake (TDMI, kg DM/day) for cows on L, H, L-H, H-L treatment groups during weeks before (6, 4, and 2) and after calving (2, 4, 6, 8, 10, 12, 14 and 16)

Factor	Weeks before calving			Weeks after calving							
	6	4	2	2	4	6	8	10	12	14	16
BDMI											
L	5.8 ^a	5.5 ^a	4.7 ^a	4.5 ^a	5.0 ^a	5.3 ^a	6.3 ^a	6.6 ^a	6.5 ^a	6.4 ^a	6.4 ^a
H	5.9 ^a	5.8 ^a	4.9 ^a	4.6 ^a	5.5 ^a	5.6 ^a	6.4 ^a	6.6 ^a	6.5 ^a	6.4 ^a	6.6 ^a
L-H								7.5 ^a	7.4 ^a	7.3 ^a	7.1 ^a
H-L								7.2 ^a	7.3 ^a	7.0 ^a	6.8 ^a
SE	0.01	0.03	0.02	0.01	0.05	0.03	0.01	0.1	0.08	0.09	0.08
TDMI											
L	7.8 ^b	7.5 ^b	6.7 ^b	6.5 ^b	7.0 ^b	7.3 ^b	8.3 ^b	8.6 ^b	8.5 ^b	8.4 ^b	8.4 ^b
H	9.9 ^a	9.8 ^a	8.9 ^a	8.6 ^a	9.5 ^a	9.6 ^a	10.4 ^a	10.6 ^a	10.5 ^a	10.4 ^a	10.6 ^a
L-H								11.5 ^a	11.4 ^a	11.3 ^a	11.1 ^a
H-L								9.2 ^b	9.3 ^b	9.0 ^b	8.8 ^b
SE	0.17	0.19	0.20	0.19	0.22	0.39	0.17	0.22	0.23	0.23	0.2

L: Cows on low level of concentrate supplementation (2 kgDM/day).

H: Cows on high level of concentrate supplementation (4 kgDM/day).

L-H: Cows shifted from low to high level of concentrate supplementation (4 kgDM/day).

H-L: Cows shifted from high to low level of concentrate supplementation (2 kgDM/day).

^{ab} Means within a column with different superscripts in a factor differ significantly ($p < 0.05$).

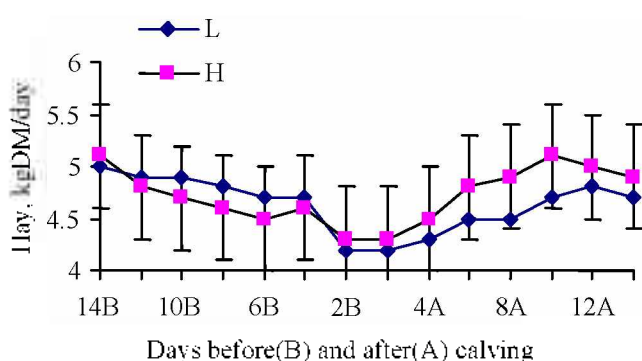


Figure 1. Daily dry matter intake of hay for cows on high (H) and low (L) plane of nutrition during the periods 14 days before (B) and after (A) calving.

partum are shown in Table 4. The data for week 9 is not shown in the table because the body weight measurements were taken once every two weeks. Body weight differed between treatments after treatment reallocation ($p < 0.05$). Body weight of cows on L-L and L-H tended to be lower compared to those on H-H and H-L. Cows on H-H, L-H and H-L were gaining weight or had reached a constant weight compared to those on L-L by week 14. Body weight change also differed between treatments ($p < 0.05$) with cows on H-H and L-H having a greater gain than on L-L and H-L. Body condition differed between treatments ($p < 0.05$) at week 10, 12 and 16 post partum, with cows on H-H and H-L having greater body condition score than those on L-L and L-H.

Milk yield and milk composition

Data for daily milk yield, days milk recorded and average milk yield are shown in Table 5.

Before treatment reallocation at 2 to 8 weeks *post partum*, daily milk yield and total milk yield for the first 49 days (excluding milk for week 1) differed between treatments ($p < 0.05$) with cows on H producing more milk per day than L (6.2 kg vs 5.0 kg/day) and average milk yield (304 kg vs 247 kg), respectively. After treatment reallocation, during week 9 to 18, daily milk yield did not differ between treatments and on average cows on L-L, H-H, L-H and H-L produced 4.3, 5.2, 4.8 and 4.7 kg, respectively. Cows that were transferred to L-H produced relatively more milk compared to cows that continued on L-L (4.8 vs 4.3 kg milk/day, respectively). However, cows transferred to H-L produced less milk compared to those that continued on H-H (4.7 vs 5.2 kg milk/day) Reallocation of treatments resulted into cows on L-H and H-L producing similar quantity of milk (4.8 vs 4.7 kg milk/day).

Regardless of treatments the longest and shortest lactation length was 280 and 122 days, respectively. All cows showed poor persistency after peak yield such that some cows started to produce less than 4 kg milk per day week 19 after calving and about half of the cows produced less than 4 kg milk per day on week 24 after calving (Figure 2). Only one cow on L treatment produced above 4 kg milk per day up to the end of week 40.

The amount of milk suckled by the calves (Table 5) did not differ significantly between treatments and averaged 2.8 and 2.7 kg per day for calves from the cows on H and L plane of nutrition. Calf daily weight gain was also fairly similar although calves from cows that were on H tended to have higher gains than the calves from cows on L plane of nutrition (241 g vs 233 g, respectively).

Data for milk composition during the first part of lactation (week 2-8) and second part of lactation (week 9-18) of cows on treatments L-L, H-H, L-H and H-L are

Table 3. Body weight (kg), body weight change (kg/day) and body condition (score) during weeks before and after calving of cows on low plane of nutrition (L) and high plane of nutrition (H)

Parameter	Weeks before calving				Weeks after calving			
	8	6	4	2	2	4	6	8
Body weight								
L	333.2 ^a	334.1 ^a	334.7 ^a	331.7 ^a	294.0 ^a	284.1 ^b	266.7 ^b	271.5 ^b
H	322.0 ^a	317.3 ^a	322.2 ^a	321.0 ^a	285.5 ^a	292.9 ^a	294.1 ^a	297.8 ^a
SE	4.15	6.28	6.71	7.14	7.23	8.01	10.63	8.33
Weight change								
L		0.18 ^a	-0.02 ^a	-0.18 ^a		-0.52 ^b	-0.50 ^b	-0.16 ^b
H		-0.30 ^a	0.29 ^a	-0.19 ^a		0.37 ^a	0.10 ^a	0.12 ^a
SE		0.49	0.24	0.57		0.10	0.11	0.07
Body condition								
L	6.8 ^a	6.7 ^a	6.8 ^a	6.7 ^a	5.9 ^b	5.8 ^b	5.6 ^b	5.5 ^b
H	6.7 ^a	6.3 ^a	6.5 ^a	6.3 ^a	6.4 ^a	6.5 ^a	6.5 ^a	6.6 ^a
SE	0.34	0.34	0.34	0.23	0.22	0.22	0.21	0.25

L: Low level of concentrate supplementation (2 kgDM/day).

H: High level of concentrate supplementation (4 kgDM/day).

^{ab} Means within a column in a parameter with different superscript differ significantly ($p < 0.05$).**Table 4.** Body weight (kg), Body weight change (kg/day), and Body condition (score) of cows on L-L, H-H, L-H and H-L plane of nutrition treatment groups after treatment reallocation in week 9

Factor	Weeks after calving				
	10	12	14	16	18
Body weight					
L-L	269.5 ^d	274.2 ^c	269.3 ^c	272.0 ^c	269.8 ^d
H-H	298.5 ^b	295.8 ^b	296.3 ^a	299.0 ^a	295.0 ^b
L-H	275.7 ^c	276.7 ^c	277.3 ^b	277.5 ^b	276.8 ^c
H-L	314.0 ^a	311.7 ^a	309.2 ^a	308.0 ^a	306.0 ^a
SE	13.76	14.61	14.15	13.85	13.34
Weight change					
L-L		0.33 ^a	-0.34 ^c	0.19 ^a	-0.15 ^c
H-H		-0.19 ^c	0.04 ^a	0.19 ^a	-0.29 ^a
L-H		0.10 ^b	0.05 ^a	0.01 ^b	-0.05 ^b
H-L		-0.17 ^c	-0.18 ^b	-0.08 ^c	-0.15 ^c
SE		0.11	0.09	0.08	0.07
Body condition					
L-L	5.8 ^b	5.8 ^b	5.8 ^a	5.8 ^b	5.6 ^a
H-H	7.2 ^a	7.2 ^a	6.8 ^a	7.2 ^a	6.5 ^a
L-H	5.8 ^b	6.0 ^b	6.0 ^a	5.8 ^b	6.2 ^a
H-L	6.7 ^b	6.3 ^b	6.5 ^a	6.3 ^b	6.2 ^b
SE	0.41	0.39	0.43	0.40	0.38

L-L: Cows on low level of concentrate supplementation (2 kgDM/day) throughout the study.

H-H: Cows on high level of concentrate supplementation (4 kgDM/day) throughout the study.

L-H: Cows shifted from low to high level of concentrate supplementation after 8 w of study.

H-L: Cows shifted from high to low level of concentrate supplementation after 8 w of study.

^{ab,c,d} Means within a column in a factor with different superscripts differ significantly ($p < 0.05$).

shown in Table 6. Before treatment reallocation, during the first 8 weeks, CP and ash components of milk differed between treatment ($p < 0.05$) while BF (butterfat) and TS (total solids) were similar across the treatments. Also during this period the difference in milk components between

Table 5. Daily milk yield (kg/day), days milk recorded and average milk yield (kg) for cows on L, H (2-8 week), L-L, H-H, L-H and H-L (9-18 week) treatment groups after calving. The amount of milk suckled by the calves is shown separately

Parameter	N	Daily milk yield	Milk yield	Days milk recorded
2-8 weeks				
L	12	5.0 ^b	247 ^b	49
H	12	6.2 ^a	304 ^a	49
SE		0.08	3.98	
CL	12	2.7 ²	122 ¹	45
CH	12	2.8 ²	126 ¹	45
SE		0.32	0.10	
9-18 weeks				
L-L	6	4.3 ^a	301.9 ^a	70
H-H	6	5.2 ^a	364.2 ^a	70
L-H	6	4.8 ^a	335.6 ^a	70
H-L	6	4.7 ^a	333.4 ^a	70
SE		0.07	4.91	70

N: Number of cows within treatment groups.

CL: Calves from cows that were on L plane of nutrition.

CH: Calves that were on H plane of nutrition.

¹ Estimated amount of milk (kg) consumed by calves in a period of 45 days.² Estimated daily milk consumption (kg) by calves.^{ab} Means within a column with different superscripts differ significantly ($p < 0.05$).

samples collected during milking and suckling was significant ($p < 0.05$), with concentrations increasing from sample 1 to sample 4 (Table 6). However, as compared to sample 4 (residual milk from the three hand milked teats), lower BF and TS were observed in sample 5, which included residual milk from the suckled fourth quarter. After treatment reallocation milk components were similar between treatments (Table 6, week 9-18).

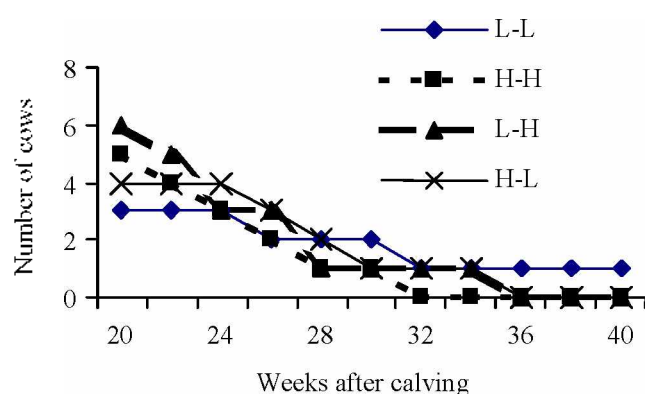


Figure 2. Number of cows remaining on L-L, H-H, L-H and H-L plane of nutrition after removing those producing less than 4 kg milk per day.

Table 6. Milk composition (g/kg) for cows on L, H (2-8 week), L-L, H-H, L-H and H-L (9-18 week) treatment groups after calving

Factor	Milk composition (g/kg)			
	Protein	Butter fat	Ash	Total solids
Week 2-8				
Treatment				
L	28 ^a	44 ^a	6 ^a	123 ^a
H	24 ^b	43 ^a	5 ^b	122 ^a
SE	0.8	1.8	0.2	2.2
Sample ¹				
1	23 ^c	39 ^c	5 ^b	115 ^c
2	25 ^b	43 ^b	5 ^b	123 ^b
3	26 ^b	45 ^b	5 ^b	126 ^a
4	27 ^a	51 ^a	6 ^a	125 ^a
5	26 ^b	40 ^c	5 ^b	122 ^b
SE	1.3	2.6	0.3	3.3
Week 9-18				
Treatment				
L-L	20 ^a	43 ^a	6 ^a	123 ^a
H-H	22 ^a	43 ^a	6 ^a	121 ^a
L-H	21 ^a	42 ^a	6 ^a	122 ^a
H-L	21 ^a	43 ^a	6 ^a	125 ^a
SE	1.0	3.0	0.3	2.2

¹ Samples taken to assess efficiency of hand milking and calf sucking in emptying the udder.

^{a,b,c} Means within a column in a factor with different superscripts differ significantly ($P < 0.05$).

DISCUSSION

Chemical composition of the grass hay used in this study indicates the nature of most of the tropical roughages, that is they are characteristically low in nutritive value, usually below 55% digestibility and often with less than 8% crude protein (Leng, 1991). The composition of sunflower cake, maize bran and estimated energy content of the concentrate mixture were similar to values reported previously in the same study area (Bwire and Wiktorsson, 1996). The high fibre content and low crude protein

percentage in the grass hay refusals compared to those in grass hay offered suggests selection of hay usually seen when excess roughage to the estimated intake is offered in order to increase intake of the basal diet. This is a result of the tendency for the animals to select the most nutritious leafy materials compared to less nutritious or stemmy parts (Bwire, 1995; Mbwire and Uden, 1997). The concentrate supplementation was such that all the quantities were consumed resulting in no refusals yet this did not lead into a significant effect in hay intake, as is often the case with low quality tropical roughages (Bwire and Wiktorsson, 1996; Shayo et al., 1997).

Supplementation resulted in increased total dry matter intake, indicating a mere additive effect (Bwire, 1995; Shayo et al., 1997). Preston and Leng (1987) explained that some supplements have a low 'rumen load' and would leave the rumen quickly and have little effect on rumen distension, and therefore intake of the basal feed remains unchanged. A substantial reduction of feed intake in pregnant cows towards calving, which continues in early part of lactation is a common phenomenon in dairy cows (Bines, 1979). This kind of phenomenon was also observed in this study where the pregnant dual-purpose cows showed a general trend in feed intake reduction in all treatments towards calving but began to rise again on day 2 after calving (Figure 1). The decline in intake during late pregnancy is probably partly due to a reduction in volume of the abdominal cavity caused by the presence of the foetus and fat deposits, and also to the increasing blood level of oestrogen (Bines, 1979), while the lag in intake after calving was suggested as being physical in origin, possibly caused by the time taken for amniotic fluid, the foetus and the foetal membranes present within the abdomen at the time of calving to be removed before the rumen can expand to its maximum (Ingvarsen and Andersen, 2000). According to Grummer (1995) the reasons behind the reduction in dry matter intake could be endocrine related. The extent of reduction varies, but a 30% reduction is typical in high yielding dairy cows (Bertics et al., 1992; Grummer et al., 1995). However, the lag in intake after calving was not observed in the present study with dual-purpose cows and the reasons behind the rapid increase in intake after calving could not be established.

In the present study a reduction in body weight was observed before and after calving, cows with higher body weight showed a reduction in body weight for a longer period, while cows with lower body weight started gaining weight earlier or attained constant body weight. Also cows that were in a slightly higher body condition before calving (L) lost weight for a longer time than cows that were in slightly lower body condition (H), and after calving the H group gained weight earlier than L. Gamsworthy and Jones (1987) also found that cows that were in a fatter condition

at calving lost more live weight and body condition over a longer period than cows calving in a lower body condition. In earlier study, Garnsworthy and Topps (1982) also found the similar results, and in all the studies it was concluded that cows with lower condition scores at calving produced more milk directly from food rather than via body fat. The dry matter intake in this study was fixed at 2 or 4 kg DM of concentrate supplementation and therefore the difference in dry matter intake (DMI) could not be associated with body condition. However, in other studies cows with lower body condition at calving were found to have higher DMI than cows with higher body condition after calving (Land and Leaver, 1980; Garnsworthy and Topps, 1982; Garnsworthy and Jones, 1987). In the present study body condition before calving was similar among treatments, although cows on L plane of nutrition tended to have higher body condition score the whole of pre-calving period, and this was due to the influence of the body condition they had at the start of the experiment. However, no influence was found between pre-calving body condition and milk yield. In other studies higher body condition at calving was found to be associated with increased milk yield (Land and Leaver, 1980; Land and Leaver, 1981). In this study provision of 4 kg DM concentrate per day both pre-calving and post-calving resulted into higher body condition score after calving and was found to influence milk yield, with cows that were on H plane of nutrition producing more milk than those on L plane of nutrition due to higher DMI for cows on H than on L.

Nine weeks after calving when the animals were re-allocated to treatments, switching cows from H to H-L (4 kg concentrate DM/day to 2 kg concentrate DM/day) reduced daily milk yield significantly by 10%. The change from H to L resulted not only in reduced milk yield but also reduced body weight and a gradual decrease in body condition score. Conversely, cows transferred from L plane of nutrition to L-H (2 kg concentrate DM/day to 4 kg concentrate DM/day), increased daily milk yield by 12% and showed a gradual increase in body condition. Cows that continued on H and L planes of nutrition had the highest and lowest daily milk yield, respectively. Most of the cows showed a poor persistency in milk yield such that only one cow produced 4 kg milk per day up to end of week 40 after calving. The reasons for the observed poor persistency are not apparent bearing in mind the small sample size but could be due to the inherent nature of the dual-purpose Mpwapwa dairy cows in that they are of low genetic potential for milk production (Mchau, 1988). According to Mchau (1988) average milk production per day for long (above 200 days) and short (less than 200 days) lactation lengths was 5.4 and 3.8 kg, respectively. The other explanation for the observed short lactation length and poor persistency is that some of the cows have a tendency of

failing to letdown milk following weaning the calves.

The calves from those cows that were on H plane of nutrition tended to have a higher growth rate compared to counterparts from cows that were on L plane of nutrition (241 g vs 233 g per day, respectively) which could be due to the slightly higher milk intakes (2.8 kg vs 2.7 kg per day, respectively). Similar findings were reported by Das et al. (1999) where calves from cows that were under a restricted suckling calf management system and were given higher concentrate supplementation, had significantly higher growth rate compared to the calves from cows that had lower levels of concentrate supplementation during the first three months after calving.

Milk components were similar between treatments. Fat, which is known to be the most variable component of milk was similar between treatments, which could be due to the fact that the concentrates contributed less than 45% of the total dry matter of the feeds consumed. According to Clark and Davis (1980) increasing the proportion of concentrate above 60% of the total dry matter of feeds might result in metabolic disorders and milk fat depression for the high yielding cows. In crossbred cows a decrease in fat content was also noted as a result of increased concentrate ratio (Sanh et al., 2001) Milk crude protein content was generally low, and was found to vary between the treatments in the first part of lactation and decreased in the second part of lactation. This was not related to the concentrates offered but rather was due to stage of lactation as milk protein is known to decrease slowly from 15 days to 45 days post partum but increase again towards the end of lactation (McDonald et al., 1988). The difference observed in milk components, particularly fat, between the main residual milk samples could be related to milk secretions and agree with the common observation of increased fat content in later fractions during milking. It is also an indication that the hand milking method, and succeeding calf sucking led to a thorough emptying of the cow's udder. The decrease in milk fat percentage following mixing with milk from the rear right hand quarter that was not hand milked (Sample 5) could be an indication that there was still some milk in that udder quarter, which possibly was emptied thoroughly when the calf was allowed to stay and socialise with the dam after the milking.

In conclusion these results show that pre-calving and post-calving concentrates supplementation improved live weight, body condition and milk yield of the dual-purpose Mpwapwa cows. The most appropriate feeding strategy could be to have concentrate supplementation which could support a standard body condition before and after calving about 4 kg DM/day, or depending on price situation of concentrates and milk, 4 kg DM/day up to 8 weeks post partum, followed by reduced amount of concentrate (2 kg DM/day) for the remainder of lactation. In general the dual-

purpose Mpwapwa breed cows showed a low genetic potential for milk production.

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